

U.S. Application No.: 10/525,939
Amendment A

Attorney Docket No. 3875.041

REMARKS

Review and reconsideration of the Non-Final Office Action of November 13, 2006 (hereinafter "Office Action"), is respectfully requested in view of the above claim amendments and the following remarks. In the Office Action, claims 1-44 were rejected (Applicants note that claim 2 was previously canceled). By the present Amendment, claims 1-25 and 27-35 & 37-44 are amended and claims 45 - 47 are added. No new matter is presented.

Claim Amendments

Claims 1-25 and 37-44 were amended to clarify that the claimed pure chromium dioxide of the claimed invention is produced and exists in bulk form. This excludes thin films of chromium dioxide deposited on a non-CrO₂ substrate using a chemical vapor deposition process. Support for this amendment may be found throughout the specification, including paragraphs [0035] & [0097], 1st line of p. 29.

Claim 3 was amended to recite that the 126emu/g saturation magnetization may be achieved when the pure bulk chromium dioxide is synthesized from Cr₈O₂₁ in pellet form. Support for this can be found throughout the specification, including Examples V and VI described in paragraphs [0073]–[0080].

Claim 4 was amended to recite that the 132-135 emu/g saturation magnetization may be achieved when the pure bulk chromium dioxide is synthesized from Cr₈O₂₁ in powder form. Support for this can be found throughout the specification, including Examples I & III described in paragraphs [0062]–[0065] & [0067].

Claim 25 was amended to insert the limitation of "heating an intermediate oxide, primarily Cr₈O₂₁ from about room temperature to a temperature of between 350 and 500°C."

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Support for "heating the intermediate oxide, primarily Cr_3O_{21} , ... from about room temperature" can be found throughout the specification, including paragraphs [0041] & [0068].

Claim 34 is amended to specifically recite an inert tube. Support for this amendment may be found throughout the specification, including paragraphs [0042] & [0053].

Claims 39-41 have also been amended to recite the "heating the intermediate oxide, primarily Cr_3O_{21} , ... from about room temperature" element. Support for this amendment can be found throughout the specification, including paragraphs [0041] & [0068].

New claim 47 is drawn to the pure bulk chromium dioxide of claim 1, wherein the pure chromium dioxide is in the form of a sintered pellet. Support for this amendment can be found throughout the specification, including paragraph [0068]-[0071].

By this Amendment, the 35 U.S.C. § 112, second paragraph, rejections imposed by the Office Action are addressed by amendments to Claims 6-13, 16-21, 27, 28, 31, 32 & 40. Claims 27 & 28 were amended to keep the broad range, but eliminate the range within a range portion. New claims 45 and 46 are drawn to the subject matter eliminated from claims 27 & 28, respectively.

Claims 6-13 & 16-20 were amended simply to change "near room temperature" to "about room temperature." Descriptions of magnetoresistance measurements being taken at "near room temperature" are found throughout the specification, including paragraphs [0029], [0030] & [0032] - [0034]. Since "about" is considered more definite by the PTO, Applicants make this amendment to recite "about," which is encompassed by the allegedly less definite term "near."

Claims 21 and 40 were amended to replace the phrase "cold and sintered form" with the phrase "powder form and pellet form." This eliminates the term "cold," which the Office Action

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challenges, from the claims. Support for the "powder form and pellet form" phrase can be found throughout the specification, including paragraphs [0062]–[0065], [0067] and [0073]–[0080].

Claims 31 and 32 were amended to eliminate the reference to "heated slowly" and "cooled slowly," respectively. The examiner indicated that "slowly" is a relative term that renders the claim vague and indefinite.

Claims Rejections – 35 USC § 102 & 103

The Office Action rejected claims 1-44 under 35 U.S.C. § 102(b) as being anticipated by or, in the alternative under 35 U.S.C. § 103(a) as being obvious over, the article titled "Epitaxial growth of CrO₂ Thin Films by Chemical-Vapor Deposition from a Cr₈O₂₁ Precursor," by Ivanov et al. (hereinafter "Ivanov").

Before addressing the cited art, Applicants wish to review the claimed invention. As set forth in amended claim 1, the invention is drawn to a substantially pure *bulk* chromium dioxide having saturation magnetization of at least about 120 emu/gm. "Bulk" as used by those skilled in the art refers to loose particles, not films.

As set forth in amended claim 25, the bulk CrO₂, or bulk composites of CrO₂ with Cr₂O₃ and CrO₂ with Cr₂O₅ are formed from heating an intermediate oxide, primarily Cr₈O₂₁, *from about room temperature* to a temperature of between 350 and 500°C for a period of between 1-5 hours, whereby substantially pure chromium dioxide (CrO₂), or composites of chromium dioxide or chromium sesquioxide (CrO₂/Cr₂O₃) or composites of chromium dioxide and Cr₂O₅ (CrO₂/Cr₂O₅) are formed. As will become apparent, the element of heating the intermediate oxide (Cr₈O₂₁) not the CrO₃ starting material, *from about room temperature to a temperature of between 350 and 500°C* is not disclosed or suggested by the cited art. In particular, the claimed ranges of 390-400 for CrO₂, 400-500 for Cr₂O₃/CrO₂, and 350-390 for Cr₂O₅/CrO₂ are neither disclosed nor suggested by the cited art.

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The Office Action asserts that Ivanov discloses the formation of a composition of the general formula CrO_x where x may vary from 1.50 to 3.00 at temperatures ranging from 200°C to 450°C. The Office Action states that CrO_2 is formed at a temperature of about 375°C and that Ivanov produced CrO_2 by decomposition of a Cr_8O_{21} precursor. The Office Action notes that graph 1 shows the formation of various oxides, such as CrO_3 , Cr_8O_{21} , Cr_2O_5 and Cr_2O_3 . Finally the Office Action notes that p. 1037, col 2, 1st full paragraph reports that "heating for shorter times or at intermediate temperatures gave powders that showed combinations of these phases..." The Office Action asserts that the only difference between the claimed invention and Ivanov is the heating time and thus the CrO_2 formed using both techniques would have the same properties. Applicants respectfully disagree for at least the reasons set forth below.

Ivanov is engaged in research to determine if an intermediate chromium oxide is created during the chemical vapor deposition (CVD) technique first disclosed by Ishibashi. Applicants point out that CVD techniques, such as the Ishibashi technique relied upon by Ivanov, are used to apply a thin film of a material onto a substrate, *not for the creation of a bulk raw material*. This is clear since Ivanov deals with "epitaxial growth of CrO_2 thin films by chemical-vapor deposition from a Cr_8O_{21} precursor." Epitaxial is a term used in crystallography to mean "an oriented overgrowth of crystalline material upon the surface of another crystal of *different chemical composition* but similar structure," See Random House Unabridged Dictionary, © Random House, Inc. 2006. This use of epitaxial is confirmed by Ivanov's disclosure that the substrate on which the chromium dioxide is deposited could be a sapphire $\text{Al}_2\text{O}_3(0001)$ wafer, see Ivanov, p. 1036, col. 1, 2nd full paragraph, or rutile $\text{TiO}_2(110)$, see Ivanov, p. 1036, col. 1, 3rd full paragraph. Thus, *particles formed using the Ivanov are not pure bulk chromium dioxide* since they necessarily include a core with a different chemical composition. On these facts alone, independent claims 1, 25 & 39 and all claims dependent thereon are drawn to allowable subject matter.

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The Ishibashi CVD technique utilizes a two zone approach. A source material, such as chromium trioxide (CrO_3) powder, is placed in a first zone and heated to 260°C and a substrate, such as a sapphire $\text{Al}_2\text{O}_3(0001)$ wafer, is placed in a second zone at 400°C , *see Ivanov*, p. 1036, 1st column, second full paragraph. The vapor released by sublimation of chromium trioxide (CrO_3) powder flows into the second zone where a thin film of chromium dioxide (CrO_2) is deposited on the sapphire $\text{Al}_2\text{O}_3(0001)$ wafer. Ivanov's research focuses on the volatile compound that decomposes onto the substrate at 390°C to produce a CrO_2 film on the substrate, *see Ivanov*, p. 1036, 1st column, fourth full paragraph.

Ivanov's research is broken into two stages:

First, Ivanov describes the results of his experiments where CrO_3 was heated in a single step to produce various chromium oxides, specifically CrO_3 , Cr_8O_{21} , Cr_2O_5 and Cr_2O_3 , *see Ivanov*, Figure 1 and p. 1037, 2nd column, first full paragraph. The Office Action uses this list of specific chromium oxides to assert that Ivanov discloses CrO_x where $x = 1.50$ to 3.00 . The endpoints, $x = 1.50$ and $x = 3.00$, mentioned by the Office Action are correct; however, Ivanov did not produce every conceivable value of x between 1.5 and 3.0. A fact that is expressly confirmed where Ivanov discloses that "no other chromium suboxides (even CrO_2) have been observed in any XRD data from the $[\text{CrO}_3]$ powders we have prepared or in the literature," *see Ivanov*, Figure 1 and p. 1037, 2nd column, first full paragraph, last sentence. Clearly, Ivanov does not disclose or suggest using heating to convert bulk CrO_3 or bulk Cr_8O_{21} into bulk CrO_2 or either of the claimed homogenous bulk materials of CrO_2 with Cr_2O_3 or CrO_2 with Cr_2O_5 .

Ivanov's second stage utilized the various chromium oxides, *i.e.* CrO_3 , Cr_8O_{21} , Cr_2O_5 and Cr_2O_3 , produced by the first stage in order to determine if these chromium oxides were the volatile compound that decomposed onto sapphire $\text{Al}_2\text{O}_3(0001)$ wafer substrate at 390°C to produce a CrO_2 film on the a sapphire $\text{Al}_2\text{O}_3(0001)$ wafer substrate, *see Ivanov*, p. 1036, 1st column, fourth full paragraph. Ivanov's research concludes that Cr_8O_{21} is likely the volatile

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compound because it was the only chromium oxide Ivanov was able to use the Ishibashi CVD technique to deposit a CrO_2 film onto a substrate. Ivanov used the same conditions as used in the Ishibashi CVD technique, *i.e.* the Cr_8O_{21} source material was exposed to 260°C and a substrate, sapphire Al_2O_3 wafer or rutile TiO_2 , was placed in a second zone at 400°C , *see Ivanov*, p. 1037, 2nd column, last paragraph - p. 1038, 1st column. Nowhere does Ivanov disclose or suggest heating Cr_8O_{21} from room temperature to a temperature between 350°C and 500°C in order to produce a bulk chromium dioxide as in the claimed invention. As recited above, since Ivanov's process deposits a thin film of CrO_2 onto a non- CrO_2 substrate, it is not capable of creating a pure bulk chromium dioxide. Clearly, Ivanov neither discloses nor suggests using heat to convert bulk CrO_3 or bulk Cr_8O_{21} into bulk CrO_2 or any of the claimed homogenous bulk materials of CrO_2 with Cr_2O_3 and CrO_2 with Cr_2O_5 .

Ivanov explicitly states "**no other chromium suboxides (even CrO_2) have been observed in any XRD data from the $[\text{CrO}_3]$ powders we have prepared or in the literature,**" *see Ivanov*, Figure 1 and p. 1037, 2nd column, first full paragraph, last sentence. Thus, Ivanov was unable to convert CrO_3 powder directly into CrO_2 powder using sequential heating and cooling steps. He also states that nothing in the literature teaches a method of converting CrO_3 powder directly into CrO_2 powder using sequential heating and cooling steps. The only method Ivanov disclosed of producing pure CrO_2 was as a **film on a non- CrO_2 substrate** using CVD with CrO_3 or Cr_8O_{21} as the source material. Thus, Ivanov does not disclose or suggest a method of producing a substantially pure **bulk** chromium dioxide having saturation magnetization of at least 120 emu/gm or even a substantially pure **bulk** chromium dioxide for that matter. Similarly, Ivanov does not disclose or suggest a method of producing the claimed homogenous bulk materials of CrO_2 with Cr_2O_3 or CrO_2 with Cr_2O_5 .

As noted in the specification, *see paragraphs* [0044]-[0049], the invention as set forth in amended claims 1 and 25, and the claimed dependent thereon, is different from the state of the art in both physical properties and in the method of producing the material. As for physical

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properties, none of the cited art discloses or suggests a substantially pure bulk chromium dioxide having saturation magnetization of at least 120 emu/gm. The closest known bulk chromium dioxide is a powder produced by DuPont that exhibits a saturation magnetization of about 100-110 emu/gm, *see specification* [0010] and Dai, J. & Tang J., "Junction-like magnetoresistance of intergranular tunneling in field-aligned chromium dioxide powders" 54434-1 at 54434-2, 1st column.

As noted by Ivanov, neither Ivanov's technique nor any technique in the literature discloses a method of converting CrO_3 or Cr_8O_{21} into bulk CrO_2 , whether alone or in combination with other chromium oxides, by a series of heating and cooling steps, *see Ivanov*, Figure 1 and p. 1037, 2nd column, first full paragraph, last sentence. As discussed above, Ivanov discloses a CVD method of heating a Cr_8O_{21} source material to 260°C and allowing the vapor to deposit on a non- CrO_2 substrate exposed to 400°C. Thus, neither Ivanov nor any other cited reference disclose or suggest the claimed method producing a substantially pure bulk chromium dioxide by heating an intermediate oxide, primarily Cr_8O_{21} , from about room temperature to a temperature of between 350 and 500°C for a period of between 1-5 hours. Accordingly, Applicants believe the claimed substantially pure bulk chromium dioxide, whether alone or in combination with other chromium oxides, and the claimed methods of producing these chromium dioxide compositions are drawn to allowable subject matter.

Applicants believe that the independent claims are allowable and thus all claims dependent thereon are also allowable. However, Applicants believe that based on the above discussion many of the dependent claims are drawn to independently patentable subject matter.

For instance, claims 3 and 47, drawn to substantially pure chromium dioxide sintered pellets, are believed to be independently patentable. The claimed method includes creating pellets of Cr_8O_{21} by sintering Cr_8O_{21} powder pressed into pellets at 250°C for a few hours. Once the sintered Cr_8O_{21} pellet are formed, the Cr_8O_{21} is converted into CrO_2 by heating the sintered

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Cr₈O₂₁ pellets to a temperature between 350°C and 500°C for 1 hour to 5 hours, *see specification*, paragraph [0081].

It is well known that prior art techniques are not capable of making *substantially pure* chromium dioxide *sintered* pellets. The prior art techniques use cold pressing or binding agents, rather than sintering. Binding agent are necessary because chromium dioxide is metastable and cannot be sintered prior to degrading, which occurs at temperatures of 200°C or greater. This leaves cold pressing using binding agents, which may depolarize the spin, *see paragraph* [0034], as the primary prior art method of forming chromium dioxide pellets. Clearly, none of the cited references disclose a substantially pure chromium dioxide pellet or a substantially pure chromium dioxide sintered pellet or a method of creating such a sintered pellet. Accordingly, Applicants believe that all claims drawn to substantially pure chromium dioxide sintered pellets and the method of creating such sintered pellets are drawn to allowable subject matter.

In addition claim 34 is drawn to the process of claim 25, wherein, prior to heating the intermediate oxide, Cr₈O₂₁, in either powder form or pellet form is sealed in an inert tube. Ivanov's procedure does not disclose placing the intermediate oxide, Cr₈O₂₁, in a sealed tube prior to heating, *see* Ivanov, p. 1037, col. 2, 1st full paragraph. Ivanov discloses that the Cr₈O₂₁ was heated under flowing oxygen at atmospheric pressure, *see id.* Because heating causes gases to expand and the inert tube is sealed, the pressure would significantly exceed atmospheric pressure when the tube and its contents are heated to between 350 and 500°C. Accordingly, Applicants believe that claim 34 is drawn to allowable subject matter.

The Commissioner is hereby authorized to charge the \$150 fee for examining two additional claim to Deposit Account No. 50-0951. Payment for two dependent claims is necessary since Applicants previously paid for 44 claims, but canceled dependent claim 2 in a preliminary amendment and now add dependent claims 45-47]. No additional fees are believed

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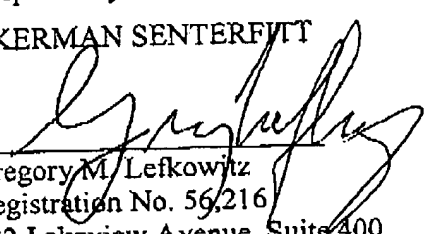
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due; however, the Commissioner is hereby authorized to charge any deficiency, or credit any overpayment, to Deposit Account No. 50-0951.

Favorable consideration and early issuance of the Notice of Allowance are respectfully requested. Should further issues remain prior to allowance, the Examiner is respectfully requested to contact the undersigned at the indicated telephone number.

Respectfully submitted,

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